

**AFRL-ML-WP-TP-2002-408**

**ADVANCED NONDESTRUCTIVE  
EVALUATION (NDE) METHODS  
Work Unit Directive (WUD) 40**



**OCTOBER 2002**

**Approved for public release; distribution is unlimited.**

**This material is declared a work of the U.S. Government and is not subject to copyright protection in the United States.**

**20030121 121**

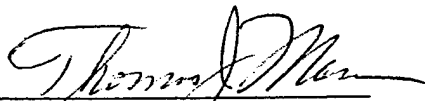
**MATERIALS AND MANUFACTURING DIRECTORATE  
AIR FORCE RESEARCH LABORATORY  
AIR FORCE MATERIEL COMMAND  
WRIGHT-PATTERSON AIR FORCE BASE, OH 45433-7750**

## NOTICE

WHEN GOVERNMENT DRAWINGS, SPECIFICATIONS, OR OTHER DATA ARE USED FOR ANY PURPOSE OTHER THAN IN CONNECTION WITH A DEFINITELY GOVERNMENT-RELATED PROCUREMENT, THE UNITED STATES GOVERNMENT INCURS NO RESPONSIBILITY OR ANY OBLIGATION WHATSOEVER. THE FACT THAT THE GOVERNMENT MAY HAVE FORMULATED OR IN ANY WAY SUPPLIED THE SAID DRAWINGS, SPECIFICATIONS, OR OTHER DATA, IS NOT TO BE REGARDED BY IMPLICATION OR OTHERWISE IN ANY MANNER CONSTRUED, AS LICENSING THE HOLDER OR ANY OTHER PERSON OR CORPORATION, OR AS CONVEYING ANY RIGHTS OR PERMISSION TO MANUFACTURE, USE, OR SELL ANY PATENTED INVENTION THAT MAY IN ANY WAY BE RELATED THERETO.

THIS REPORT IS RELEASABLE TO THE NATIONAL TECHNICAL INFORMATION SERVICE (NTIS). AT NTIS, IT WILL BE AVAILABLE TO THE GENERAL PUBLIC, INCLUDING FOREIGN NATIONS.

THIS TECHNICAL REPORT HAS BEEN REVIEWED AND IS APPROVED FOR PUBLICATION.



THOMAS J. MORAN  
Nondestructive Evaluation Branch  
Metals, Ceramics & NDE Division



CHARLES F. BUYNAK, Actg Chief  
Nondestructive Evaluation Branch  
Metals, Ceramics & NDE Division



WALTER M. GRIFFITH, Chief  
Metals, Ceramics & NDE Division  
Materials & Manufacturing Directorate

IF YOUR ADDRESS HAS CHANGED, IF YOU WISH TO BE REMOVED FROM OUR MAILING LIST, OR IF THE ADDRESSEE IS NO LONGER EMPLOYED BY YOUR ORGANIZATION, PLEASE NOTIFY, AFRL/MLLP, WRIGHT-PATTERSON AFB OH 45433-7817 TO HELP US MAINTAIN A CURRENT MAILING LIST.

COPIES OF THIS REPORT SHOULD NOT BE RETURNED UNLESS RETURN IS REQUIRED BY SECURITY CONSIDERATIONS, CONTRACTUAL OBLIGATIONS, OR NOTICE ON A SPECIFIC DOCUMENT.

<b>REPORT DOCUMENTATION PAGE</b>				<i>Form Approved</i> OMB No. 0704-0188	
The public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. <b>PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.</b>					
<b>1. REPORT DATE (DD-MM-YY)</b> October 2002		<b>2. REPORT TYPE</b> Bibliography		<b>3. DATES COVERED (From - To)</b> 10/01/1992 – 09/30/1999	
<b>4. TITLE AND SUBTITLE</b> ADVANCED NONDESTRUCTIVE EVALUATION (NDE) METHODS Work Unit Directive (WUD) 40				<b>5a. CONTRACT NUMBER</b> IN-HOUSE	
				<b>5b. GRANT NUMBER</b>	
				<b>5c. PROGRAM ELEMENT NUMBER</b> 62102F	
<b>6. AUTHOR(S)</b>				<b>5d. PROJECT NUMBER</b> 2418	
				<b>5e. TASK NUMBER</b> 02	
				<b>5f. WORK UNIT NUMBER</b> 60	
<b>7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)</b> Nondestructive Evaluation Branch (MLLP) Metals, Ceramics & Nondestructive Evaluation Division Materials and Manufacturing Directorate Air Force Research Laboratory, Air Force Materiel Command Wright-Patterson AFB, OH 45433-7750				<b>8. PERFORMING ORGANIZATION REPORT NUMBER</b> AFRL-ML-WP-TP-2002-408	
<b>9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)</b> Materials and Manufacturing Directorate Air Force Research Laboratory Air Force Materiel Command Wright-Patterson AFB, OH 45433-7750				<b>10. SPONSORING/MONITORING AGENCY ACRONYM(S)</b> AFRL/MLLP	
				<b>11. SPONSORING/MONITORING AGENCY REPORT NUMBER(S)</b> AFRL-ML-WP-TP-2002-408	
<b>12. DISTRIBUTION/AVAILABILITY STATEMENT</b> Approved for public release; distribution is unlimited.					
<b>13. SUPPLEMENTARY NOTES</b> This material is declared a work of the U.S. Government and is not subject to copyright protection in the United States. This technical paper is a bibliography.					
<b>14. ABSTRACT</b> This report consists of a compilation of publications from 1994 – 1999.					
<b>15. SUBJECT TERMS</b> Nondestructive Evaluation, Ultrasonic Inspection					
<b>16. SECURITY CLASSIFICATION OF:</b>			<b>17. LIMITATION OF ABSTRACT:</b> SAR	<b>18. NUMBER OF PAGES</b> 12	<b>19a. NAME OF RESPONSIBLE PERSON (Monitor)</b> Thomas J. Moran <b>19b. TELEPHONE NUMBER (Include Area Code)</b> (937) 255-9800
<b>a. REPORT</b> Unclassified	<b>b. ABSTRACT</b> Unclassified	<b>c. THIS PAGE</b> Unclassified			

Benson, D. M. K., P.; Matikas, T.E.; Kundu, T. (1994). "Experimental Generation of Lamb Wave Dispersion Using Fourier Analysis of Leaky Modes." 21st Annual Review of Progress in Quantitative Nondestructive Evaluation **14**.

Frantziskonis, G. N. K., P., Matikas, T.E.; Krishnamurthy, S. (1994). "Simulation of Fiber-Matrix Interface Behavior Under Various Experimental Configurations." ICCE **1**: 147-148.

Frantziskonis, G. N. K., P., Matikas, T.E.; Krishnamurthy, S.; Jero, P.D. (1994). "Fiber Matrix Interface - Information from Experiments Via Simulation." Composite Structures **29**: 231-247.

Hu, S. M., T.E.; Karpur, P. (1994). "A Preliminary Investigation of Fiber/Matrix Interphase Oxidation in Metal Matrix Composites Using Acoustic Microscope." 21st Annual Review of Progress in Quantitative Nondestructive Evaluation **14B**: 1263-1270.

Hu, S. K., P.; Matikas, T.E.; Shaw, L.; Pagano, N.J. (1994). "Free Edge Effect on Residual Stresses and Fracture of Composite Fiber/Matrix Interface." ICCE **1**: 221-222.

Karpur, P. M., T.E.; Krishnamurthy, S. (1994). "Ultrasound as a Tool for the Development of Aerospace Structural Titanium and Ceramic Matrix Composites." The Minerals, Metals & Materials Society: 241-253.

Benson, D. M. K., P.; Matikas, T.E.; Stubbs, D.A. (1995). "Evaluation of Damage Evolution and Material Behavior in SIGMA/Ti-6242 Composite Using Nondestructive Methods." ASTM STP.

Benson, D. M. K., P.; Matikas, T.E.; Stubbs, D.A. (1995). "Characterization of Damage Progression and Its Correlation to Residual Strength in a SIGMA/Ti-6242 Composite Using Nondestructive Methods." ASME Proceedings.

Hu, S. G., D.; Matikas, T.E.; Karpur, P. (1995). "Quantitative Ultrasonic Characterization of Metal Matrix Composites Fiber/Matrix Interfacial Failure." 22nd Review of Progress in Quantitative Nondestructive Evaluation **15**.

Karpur, P. M., T.E. (1995). "Shear-Wave Back Reflectivity and Acoustic Microscopy Techniques for the Characterization of Damage in Titanium Matrix Composites." Proceedings of the ASNT Spring Conference: 179-181.

Karpur, P. M., T.E.; Krishnamurthy, S. (1995). "Ultrasonic Characterization of the Fiber-Matrix Interphase/Interface for Mechanics of Continuous Fiber Reinforced Metal Matrix and Ceramic Matrix Composites." Journal of Composites Engineering **5(6)**: 697-711.

Karpur, P. M., T.E.; Blodgett, M.P.; Jira, J.R.; Blatt, D. (1995). "Nondestructive Crack Size and Interfacial Degradation Evaluation in Metal Matrix Composites Using Ultrasonic Microscopy." American Society for Testing and Materials **1251**: 130-146.

Karpur, P. B., D.M.; Matikas, T.E.; Kundu, T.; Nicolaou, P.D. (1995). "An Approach to

Determine the Experimental Transmitter-Receiver Geometry for the Reception of Leaky Lamb Waves." Materials Evaluation.

Kent, R. M. N., P.B. (1995). "Texture Assessment in SCS-6 Fibers from Ultrasonic Dispersion Measurements." Rev. of Progress in QNDE.

Kent, R. M. N., P.B.; Ruddell, M.J. (1995). "Ultrasonic Assessment of Poisson's Ratio." Journal of Acoust. Soc. Am.

Blodgett, M. P., Nagy, P.B. (1997). The Role of Grain Noise in Eddy Current Inspection of Titanium. MRS Fall Conference, Boston, MA.

Fiedler, C. J. (1997). Air Force Large Area Composite Inspection Programs. ASNT Fall Conference, Pittsburg, PA.

Fiedler, C. J. D., T.; Kwan, J.; Frazier, W.; Mattos, M. (1997). Characterization of Composite Parts Using the Laser Ultrasonic Inspection System at the Sacramento Air Logistics Center. Fourth International Conference on Composites Engineering, Hawaii.

Fiedler, C. J. D., T.; Kwan, J.; Frazier, W.; Mattos, M. (1997). Characterization of Composite Parts Using the Laser Ultrasonic Inspection System at the Sacramento Air Logistics Center. Eighth International Symposium on Nondestructive Characterization of Materials, Boulder, Colorado.

Fiedler, C. J. W., J.W. (1997). Characterization of Thin Coatings Using Ultrafast Pulses of Laser Generated Ultrasound. Eighth International Symposium on Nondestructive Characterization of Materials, Boulder, Colorado.

Frankel, G. S. Z., J.; Crane, R.L. (1997). Corrosion Sensing Paint. US Patent No. Invention Disclosure filed Oct 1997. United States.

Frock, B. K., E.; Ruddell, M. (1997). MAUS III NDE of Composite Racing Tubs at the Indianapolis Motor Speedway.

Grant, S. F. F., C.J.; Ducharme, T.; Kwan, J. (1997). Characterization of Composite Parts Using the Laser Ultrasonic Inspection System (LUIS). Defense Manufacturing Conference '97, Palm Springs, CA.

Grant, S. F. F., C.J.; Ducharme, T.; Kwan, J. (1997). Characterization of Composite Parts Using the Laser Ultrasonic Inspection System (LUIS). FAST Center for Structural Integrity of Aerospace Systems, El Paso, TX.

Hart, D. M., R.W. (1997). Analysis of Multilayer Chip Capacitors (Failure Analysis). WPAFB, Ohio, Wright Laboratory.

Hassan, W., Nagy, P.B. (1997). "Circumferential Creeping Waves Around a Fluid-Filled Cylindrical Cavity in an Elastic Medium." J. Acoust. Soc. Am. **101**(No. 5, Pt. 1): 2496.

Hassan, W. N., P.B. (1997). Dispersion and Attenuation of Circumferential Creeping

Waves Around a Fluid-Filled Cylindrical Cavity in an Elastic Medium. Proceedings of NOISE-CON 97.

Krishnamurthy, S. M., T.E.; Karpur, P. (1997). "Observations of Fiber Fragmentation Phenomena in Model Single Fiber Titanium Based Composites and Correlation with Interfacial Properties." Met. Trans.

Krishnamurthy, S. M., T.E.; Karpur, P. (1997). "Role of Matrix Microstructure in the Ultrasonic Characterization of Fiber-reinforced Metal Matrix Composites." J. Mater. Res. **12(3)**: 754-763.

Majumdar, B. S. M., T.E.; Miracle, D.B. (1997). "Experiments and Analysis of Fiber Fragmentation in Single and Multiple-Fiber SiC/Ti-6Al-4V Metal Matrix Composites." Journal of Composites B: Engineering.

Majumdar, B. S. M., T.E.; Miracle, D.B. (1997). Effects of the Interface on Local Versus Global Load Sharing Behavior in Metal Matrix Composites Under Longitudinal Tension. International Conference on Composites Materials (ICCM), Australia.

Matikas, T. E. (1997). "Nondestructive Evaluation of Laminated Composites." Composites Science and Technology.

Matikas, T. E. K., P.; Shamasundar, S. (1997). "Measurement of the Dynamic Elastic Moduli of Porous Titanium Aluminide Compacts." Journal of Material Science **32**: 1099-1103.

Matikas, T. E. K., P.; Krishnamurthy, S. (1997). "A Nondestructive Method for Detection and Mapping of Fiber Fractures in Metal Matrix Composites." Composites Science and Technology.

Matikas, T. E. S., S. (1997). "High Cycle Fatigue at 20 kHz." International Journal of Fatigue.

Mullins, W. M. I., R.D.; Malas, J.C.; Venugopal, S. (1997). "Examination on the Use of Acoustic Emission for Monitoring Metal Forging Process: A Study Using Simulation Technique." Scripta Met. **36**: 967.

Mullins, W. M. M., J.C. (1997). "Acoustic Emission for Monitoring Metal Forging Process". TMS Annual Meeting, Orlando, FL.

Mullins, W. M. S., E.J.; Tyler, G.J. (1997). "Stochastic Kinetics of Corrosion and Fractal Surface Evolution." J. Corr. Sci. Eng.

Mullins, W. M. S., S.S. (1997). "Ultrasonic Quantification of Corroded Surfaces". MRS Annual Meeting, Boston, MA.

Nerenberg, R. R., R.; Sorscher, S.; Woodmansee, W.; Fiedler, C.; Ducharme, T.; Kwan, J.; Mattos, M. (1997). Results of Laser Ultrasonic Inspection of Aircraft

Components. ASNT Spring Conference - Refining Quality with NDE, Houston, TX, ASNT.

Pachter, R. H. P., D.; Wang, Z.; Crane, R.L.; Adams, W.W. (1997). ""Natural Springs: The Prediction of the Structure and the Mechanical Response of Biomolecular Chains". Materials Science and Engineering Part C (Biomimetic Materials, Sensors, and Systems).

Sathish, S. C., R.L. (1997). "Differential Property Sensitive Acoustic Lens". United States.

Sutherland, R. L. N., L.V.; Tondiglia, V.P.; Crane, R.L. (1997). "Laser Wavelength Detection and Energy Dosimetry Badge". United States.

Yancey, R. N. (1997). "Creating Data Packages for Aircraft Resupply". Proceedings of the Materials Research Society's Symposium JJ - Nondestructive Evaluation of Materials in Aging Systems.

Blodgett, M. P. N., P.B. (1998). "Anisotropic Grain Noise in Eddy Current Imaging of Noncubic Polycrystalline Metals." Applied Physics Letters **72(9)**: 1045-1047.

Blodgett, M. P., Nagy, P.B. (1998). "Anisotropic Grain Noise in Eddy Current Inspection of Noncubic Polycrystalline Metals." Applied Physics Letters **72**(No. 9, March).

Buynak, C. P., C. (1998). Inspection Based Life Management of Engine Components. AGARD, NATO Research and Technology Organization RTO Symposium, Brussels, Belgium.

Hassan, W. (1998). Near Field Interferometric Detection of Ultrasonic Vibrations: Applications and Limitations. ASME meeting, Anaheim CA.

Matikas, T. M., R.; Sathish, S.; Mann, L. (1998). Surface Acoustic Wave Velocity Imaging Using V(Z) and Time of Flight Measurements. ASME meeting, Anaheim, CA.

Yancey, R. N., S.; Reese, G. (1998). Recent Advancements in X-Ray CT Applications. 9th Annual Advanced Aerospace Materials & Processes Conference and Exposition AEROMAT '98, Tysons Corner, VA.

Blodgett, M. H., W.; Nagy, P. (1999). "Theoretical and Experimental Investigations of the Lateral Resolution of Eddy Current Imaging." Materials Evaluation (to be published).

Blodgett, M. E., D. (1999). "The Influence of Texture and Phase Distortion on Ultrasonic Attenuation in Ti-6Al-4V." Journal of NDE (submitted for publication).

Blodgett, M. N., P. (1999). "Eddy Current Evaluation of Electrical Anisotropy in Polycrystalline Ti-6Al-4V." Review Progress in Quantitative NDE(18B): 1709-1716.

Blodgett, M. (1999). Lateral Resolution in Eddy Current Imaging for Materials

Characterization in Polycrystalline Titanium Alloys. 10th Annual Advanced Aerospace Materials & Processes Conference and Exposition, AEROMAT '99, Dayton, OH.

Crane, R. B., C. (1999). Transitioning NDE Technology to Non-Aerospace Customers. 1999 ASNT Spring Conference, Orlando, FL.

Daniels, C. R. K., E.L. (1999). Determination of Spatial Resolution in a High Resolution X-Ray Computed Tomography System. 10th Annual Advanced Aerospace Materials & Processes Conference and Exposition, AEROMAT '99, Dayton, OH.

Hassan, W. N., P. (1999). "Experimental Investigation of the Grain Noise in Interferometric Detection of Ultrasonic Waves." Journal of NDE (submitted for publication).

Hassan, W. (1999). "Investigation of the Lateral Penetration Depth of Eddy Current and Its Implications on Eddy Current Imaging Techniques." Journal of NDE (submitted for publication).

Hassan, W. (1999). "Measurements of the Fluid Effect on the Dilational Wave Velocity in Thin Plates and Rods." Journal of the Acoustical Society of America (submitted for publication).

Kropas-Hughes, C. (1999). "The Basics of Computed Tomography." Materials Evaluation.

Larsen, J. M. R., E.; Rasmussen, B.A.; John, R.; Buynak, C.F. (1999). Propulsion Life Extension Through INSpection-Based Life Management. AeroMat'99 Conference and Exposition, Dayton, OH.

Martin, R. S., S. (1999). Development of a Scan System for Rayleigh, Shear and Longitudinal Wave Velocity Mapping. 1999 IEEE International Ultrasonics Symposium, Sateline, Nevada, published in the proceedings of the 1999 IEEE International Ultrasonics Symposium.

Martin, R. S., S.; Matikas, T. (1999). "Development of a Scan System for Rayleigh Wave Velocity Mapping." Review of Progress in Quantitative Nondestructive Evaluation 18: 2031.

Martin, R. S., S. (1999). Surface Wave Velocity and Young's Modulus Imaging with a Scanning Acoustic Microscope. 10th Annual Advanced Aerospace Materials & Processes Conference and Exposition AEROMAT '99, Dayton, OH.

Matikas, T. M., R.; Sathish, S.; Mann, L. (1999). Local Elastic Property Mapping Via Automation of V(Z) Curve Measurements Using Short-Pulse Acoustic Microscopy. "Review of Progress in Quantitative Nondestructive Evaluation, Kluwer Academic/Plenum Publishers.

Moran, T. (1999). Future Directions of Air Force NDE Reserach. ASME Sixth



Nondestructive Evaluation Topical Conference, San Antonio, TX.

Sathish, S. M., M.S.; Cantrell, J.H.; Yost, W.T. (1999). "Assessment of Single Fiber Fragmentation Using Scanning Acoustic Microscopy." J. Mater. Res. **14**(2881-2887).

Sathish, S. M., R.; Every, A. (1999). "Observation of Longitudinal, Shear and Rayleigh Waves in a Scanning Accoustic, Microscope with Impluse Excitation." Applied Physics Letters.

Sathish, S. M., R.; Matikas, T. (1999). "Rayleigh Wave Velocity Mapping Using Scanning Acoustic Microscope." Review of Progress in Quantitative Nondestructive Evaluation **18**: 2025.

Sathish, S. M., M.S.; Cantrell, J.H.; Yost, W.T. (1999). "Scanning Acoustic Microscopy of Single Fiber Fragmentation." Review of Progress in Quantitative Nondestructive Evaluation **18**: 1359.

Sathish, S. M., R.; Moran, T. (1999). Acoustic Microscopy and X-ray Diffraction Measurements of Stress in Ti-6Al-4V. 10th Annual Advanced Aerospace Materials & Processes Conference and Exposition, AEROMAT '99, Dayton, OH.